CIVILIAN BLAST-RELATED BURN INJURIES

BRÛLURES PAR EXPLOSION EN PRATIQUE CIVILE

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SUMMARY. There is limited English literature describing the experience of a civilian hospital managing blast-related burn injuries. As the largest regional burn unit, we reviewed our cases with the aim of identifying means to improve current management. A 6-year retrospective analysis of all patients coded as sustaining blast-related burns was conducted through the unit's burns database. Medical case notes were reviewed for information on burn demographics, management and outcomes. 42 patients were identified. Male to female ratio was 37:5. Age range was 12-84 years, (mean=33 years). Total body surface area (%TBSA) burn ranged from 0.25% to 60%, (median=1%). The most common burn injury was flame (31/42, 73.8%). Gas explosions were the most common mechanism of injury (19 cases; 45.2%). 7/42 cases (16.7%) had full ATLS management pre-transfer to the burns unit. The Injury Severity Score (ISS) ranged from 0-43 (median=2). 17/42 (40.4%) patients required admission. 37/36 (88.1%) patients were managed conservatively of which 1 patient later required surgery due to deeper burns. 5/42 (11.9%) patients required surgical management at presentation and these were noted to be burns with >15% TBSA requiring resuscitation. One case required emergency escharotomies and finger amputations. All patients survived their burn injuries. Blast-related burn injuries are generally uncommon in the civilian setting. Following proper assessment, most of these cases can be deemed as minor injuries and managed conservatively. Improvement in burns management education and training at local emergency departments would provide efficient patient care and avoid unnecessary referrals to a burns unit.

Keywords: blast, burns, civilian, advance trauma life support (ATLS), injury severity, outcomes

***RÉSUMÉ**. La littérature anglophone concernant l'expérience des hôpitaux civils dans la prise en charge des brûlés à la suite d'une explosion. En tant que plus grand CTB de la région, nous avons revu nos cas, afin d'identifier des axes d'amélioration de notre prise en charge actuelle. Nous avons pour cela revu les dossiers des patients admis pour brûlure liée à une explosion pendant 6 ans, en nous focalisant sur les données démographiques, la prise en charge et le devenir. Quarante deux patients ont été retrouvés, dont 37 hommes et 5 femmes. L'âge moyen était de 33 ans (12-84), la surface brûlée de 1% (0,25-60), l'agent vulnérant une flamme dans 31 cas (73.8%). Une explosion de gaz était retrouvée 19 fois (45.2%). Presque tous (36 soit 88.1%) les patients étaient passés par le déchoquage avant leur admission en CTB. L'ISS s'étendait de 0 à 43 (médiane 2), 40.4% (17) d'entre eux ont été hospitalisés, presque tous (36) ont cicatrisé spontanément, le dernier ayant été greffé secondairement. Cinq patients (11.9%) ont dû être opérés d'emblée, ils avaient tous une surface brûlée de plus de 15%, nécessitant une réanimation hydro-électrolytique. Un patient a subi des incisions de décharge et une amputation digitale. Aucun décès n'a été observé. Les brûlures liées à une explosion sont rares en pratique civile. La plupart des patients ont des brûlures mineures, cicatrisant spontanément. La formation des urgentistes pourrait permettre les transferts inutiles en CTB.*

***Mots-clés**: explosion, brûlure, pratique civile, déchoquage, gravité, devenir*

Introduction

The management of blast-related burn injuries is complex due to the nature of the mechanism involved. Most studies have been conducted in the Middle East, where patients were victims of war or terror attacks. These patients were managed mostly in a military medical setting, better equipped with a protocol-driven philosophy to cope with polytrauma and concurrent burns.[1,2] There is limited English literature describing the experience of a civilian hospital managing blast-related burn injuries, mainly because these events are unusual, with cases resulting from an industrial explosion or at large festivals.[3,4] However, burn injuries can occur as a result of blasts on a smaller scale, such as from a domestic appliance or bonfire. As the largest regional burn unit, we reviewed and audited the management of all our blast-related burn cases. We hypothesise that in many cases, blast-related burn injuries in a civilian setting are often minor injuries in the absence of polytrauma, and could potentially be managed without a referral to a burns specialist unit. This would preserve resources that could be used for the management of more severe burns cases.

Methods

A 6-year retrospective analysis of all patients coded as sustaining blast-related burns was conducted through the unit's burns database. The search terms used for identifying patients on the database were "blast" and "explosion". Of the total 7702 cases in the 6 years, 51 patients were identified with the unique code from 11/05/2006 to 18/08/2014. Patient case notes were

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then requested from medical records for analysis. Our inclusion criteria was all patients admitted or seen as outpatients at our unit, who sustained a burn injury of any size and depth caused by a blast or explosion from any mechanism. We excluded any patients who were coded incorrectly on the database, i.e. patients who sustained burn injuries that were not caused by a blast or explosion. We recorded information on patient demographics, burn demographics (mechanism, location, size, depth, severity and concurrent injuries), management and outcomes. Burn size and depth at our unit is assessed by clinical examination by a senior burns specialist. In terms of management, we audited patient notes to determine if patients were ATLS cleared, if other concurrent trauma were documented and appropriate imaging reported prior to being referred to our burns unit. The key outcomes measured included the injury severity score, the healing times of burn wounds in patients managed conservatively and surgically, if admitted after initial screening in outpatients the length of stay in hospital (including length of stay in intensive care), presence of subsequent functional disability and survival rates. Healing times (time taken for re-epithelization and skin graft acceptance) was assessed from documented wound reviews and date of discharge from follow up appointments. This study was registered with Clinical Governance, code CA14-240.

Theory/calculation

The purpose of this study is to test the hypothesis that civilian blast-related burn injuries differ from blast injuries that occur in a military setting and are often associated with polytrauma. With our results, we aim to discuss the complexities of civilian blast-related burns and how these should be managed.

Results

Forty-two patients with a blast-related burn injury were identified. Nine patients had been excluded because their injuries were not blast-related. The mean age was 33 years (range 12-84 years). Male to female ratio was 37:5. Total body surface area (%TBSA) burn ranged from 0.25% to 60%, with a median of 1% TBSA. Median was measured to take into account the only 3 cases >15%.

Table I shows the etiology of the cases treated at our unit. The most common burn injury was flame (31/42, 73.8%), followed by scald (4/42, 9.5%), chemical (3/42, 7.1%), electrical (2/42, 4.8%) and contact (1/42, 2.4%). The most common mechanism involved a gas explosion (19/42, 45.2%), followed by domestic appliances (10/42, 23.8%), chemicals (5/42, 11.9%), bonfires (4/42, 9.5%) and fireworks (4/42, 9.5%). 4/19 (21.0%) gas explosions were a result of small aerosol containers and 5/19 (26.3%) involved vehicles.

The majority of burn injuries were partial thickness (23/42, 54.8%). 9/42 (21.4%) cases were mixed depth of which 7/9 (77.8%) were recorded as mixed partial thickness/deep dermal and 2/9 (22.2%) were recorded as mixed deep dermal/full thickness (*Table I*). 8/42 (19%) cases were deep dermal alone and 2/42 (4.8%) cases were full thickness burns. The upper limbs (29/42, 69.0%) and the head and neck (28, 66.7%) areas were most commonly affected, with the lower limbs (8/42, 1%) occasionally involved. Out of 42 cases, the chest, abdomen and back sustained burn injuries in 5 (11.9%), 3 (7.1%) and 4 (9.5%) cases respectively.

Environmental location of the injuries was recorded for 37/42 (88.1%) cases. 25/37 (67.6%) cases of blast-related burn injuries occurred outdoors in the open air, where the patient was in the close vicinity of a gas explosion (12/25, 48.0%), bonfire (4/25, 16.0%), fireworks (4/25, 16.0%), petrol (3/25, 12.0%) or using a domestic appliance (2/25, 8.0%). Of the 12 gas explosions where patients were injured outdoors, 5 (41.7%) involved vehicles and 4 (33.3%) resulted from aerosol containers.

12/37 (32.4%) burn injuries occurred indoors (8 cases at home, 4 cases at work). These mainly involved domestic appliances (7/12, 58.3%). 3/12 (25%) cases were the result of a gas explosion and 2/12 (16.7%) the result of a chemical explosion.

Seven of the 42 cases (16.7%) had full advance trauma life support (ATLS) management pre-transfer to our burns unit. The Injury Severity Score (ISS) ranged from 0 to 43 (median = 2). 4/42 (9.5%) cases had additional injuries that were deemed minor. These included fractures (2/42, 4.8%) and mild corneal abrasion with no residual visual loss (2/42, 4.8%), all of which were managed conservatively with appropriate specialist input. There were no cases of severe head injury or penetrating abdominal or chest injury. 17/42 (40.4%) patients required admission, 7 of which needed critical care input. The length of stay in burns ITU ranged from 1-127 days (median = 5 days). The total length of stay in hospital ranged from 1-365 days (median = 5 days). 37/42 (88.1%) patients were managed conservatively. One of them later required surgery due to deeper burns. 5/42 (11.9%) patients required surgical manage-

Table I - Mechanism of injury and injuries according to anatomical region. N = total out of 42; PT = partial thickness; DD = deep dermal; FT = full thickness

Burn Injury	N	%	Burn Mechanism	N	%
Flame	31	73.8	Gas explosion	19	45.2
Chemical	3	7.1	Domestic appliance	10	23.8
Scald	4	9.5	Chemical explosion	5	11.9
Electrical	2	4.8	Bonfire	4	9.5
Contact	1	2.4	Fireworks	4	9.5
Burn Area	**N**	**%**	**Burn Depth**	**N**	**%**
Head/neck	28	66.7	PT	23	54.8
Chest	5	13.8	Mixed (PT/DD)	7	16.7
Abdomen	3	7.1	DD	8	19.0
Back	4	9.5	Mixed (DD/PT)	2	4.8
Perineum/genitals	0	0.0	FT	2	4.8
Upper limbs	29	69.0			
Lower limbs	8	19.0			

Table II - Inhalation injury and associated mechanisms and anatomical regions. N = total out of 5 inhalation injuries; PT = partial thickness; DD = deep dermal; FT = full thickness

Burn Injury	N	%	Burn Mechanism	N	%
Flame	4	80	Gas explosion	4	80
			Domestic appliance	1	20
Burn Area	**N**	**%**	**Burn Depth**	**N**	**%**
Head/neck	5	100	PT	0	0
Chest	4	80	Mixed (PT/DD)	1	20
Abdomen	2	40	DD	1	20
Back	3	60	Mixed (DD/FT)	2	40
Perineum/genitals	0	0	FT	1	20
Upper limbs	5	100			
Lower limbs	3	60			

ment at presentation, and these were noted to be burns with >15% TBSA requiring resuscitation. One case required emergency escharotomies and finger amputations. All patients survived their burn injuries.

Bronchoscopy confirmed smoke inhalation injury in 5/42 (13.8%) cases. The %TBSA ranged from 14-60% (mean = 36.6%). *Table II* highlights the associated mechanism and pattern of burn injuries. All 5 cases required ITU input with an average length of stay in ITU of 41 days (range 2-127). Total length of stay in hospital for these patients ranged from 9-365 days. Regarding healing time, one patient was lost to follow up, while healing time for the remaining 4 patients ranged from 21-365 days (median 33 days). No deaths occurred in these patients whilst receiving care at our unit.

Regarding healing time, 12 of the total number of patients were lost to follow up with our unit. Five of them had been given open appointments where they could choose not to attend if they felt there was no need to. One patient was followed up at their local hospital. Based on the remaining 30 patients who did have follow up, the healing time ranged from 5-365 days, with a median of 17.5 days.

Discussion

Our study has shown that blast-related burn injury is generally an uncommon presentation at a regional burns unit. The majority of these burn injuries are small and therefore managed conservatively. This contrasts with the findings of studies describing the management of burns from blasts resulting in polytrauma. To the best of our knowledge, this is the largest retrospective study of civilian blast-related burn injuries in the United Kingdom to date.

In comparison to other studies investigating blast injuries that were a result of war and terrorist attacks,[1,2] the mechanism of injury in our study was generally an explosion from a gas pipe or domestic appliance, which causes less damage than war devices such as IED. Nonetheless, any explosion or blast involves sudden high pressures and velocities directed at the victim. It has been discussed that the blast wave generated by an explosion is also responsible for inducing brain injury and neurological deficit that can affect learning and short-term memory.[5,6] The lack of dangerous explosives and scrap metal that are often released as projectiles and displace body parts[7] is most likely reflected in the lower injury severity score, i.e. 2, and quicker healing time shown in our study in comparison to battle fields, landmines and terror attacks in a civilian setting. In those situations, outcomes of studies have shown higher injury severity scores with cases of missing limbs and disability.[7,8,9] The lower injury severity score reported in our study also suggests that severity of injury is proportional to the magnitude of the blast wave, which may not be significant in most cases seen in a civilian setting. The poorer outcomes in a military or war setting may also be due to a high number of severe cases and limited resources and support available. Our study revealed only one case that required emergency echarotomies and fingertip amputations.

There were 5 cases of smoke inhalation injury confirmed by bronchoscopy in our study. Four of them resulted from a gas pipe explosion. Smoke inhalation injuries are associated with high mortality.[10] This lack of inhalation referrals suggests that common mechanisms of inhalation injury are not associated with blasts, but rather with other mechanisms such as suicide attempts and industrial fires.

Given that the majority of the cases in our study were minor burn injuries with low %TBSA involvement and mainly partial thickness or mixed depth thickness, one could argue that these injuries could be managed at local hospitals without the need to transfer the patient to a burns unit. There has been much discussion on how non-specialists should be trained to provide safe burn care and avoid unnecessary referrals. The need for better training at local hospitals has been highlighted by a study showing that inaccurate TSBA calculations by non-specialists can have a significant impact on resuscitation.[11] Sozen et al. have suggested that the principles of burn management should be applied at primary and secondary centres, including making specialist dressings available to all units.[12] Burn depth in our study was assessed by at least a senior burns specialist surgeon. Various tools are also available to help assess burn depth. These include Laser Doppler imaging (LDI), noncontact/high frequency ultrasound, digital planimetry and newer 3D photography[13] and less commonly, biopsy. A recent systematic review suggests that LDI is an accurate tool and most favoured for assessing burn depth.[14] In keeping with our findings, a recent survey at Burn Centres across the United States suggests that the most common method of assessing burn depth is clinical examination alone, followed by LDI then noncontact/high frequency ultrasound.[15] Scant use of technology is most likely due to cost, availability and occasional inaccuracy due to patient factors such as tattoos, anaemia and peripheral vascular disease.[14] Whilst existing tools may not be as useful at regional units staffed with experienced burn specialists, such methods may have a more useful role at non-specialist units. Undoubtedly, our results highlight the need for better training and availability of equipment and specialised dressings for burns management at local hospitals. Implementing these changes and surveying the outcomes of managing minor burn injuries at non-specialist units may demonstrate positive patient outcomes e.g. a reduction in time taken off employment. For uncertain cases, television is becoming increasingly available, and advice can be given by specialist burns unit without the need to transfer patients. For minor injuries, Finlay et al. have shown the effectiveness of patient education on wound care, and the role of quality of life surveys in place of follow up appointments[16] in improving outcomes and quality of care, thereby avoiding unnecessary clinic appointments.

The final point we would like to address is the well-known importance of ruling out other injuries. The lack of ATLS clearance prior to referral to a burns unit shown in our review suggests that clinicians are not following well-established protocols when a patient presents with a blast-related injury. This raises a cause for concern given that on rare occasions blast-related burn injuries in a civilian setting can be complex, as shown in our study. Busche et al. have emphasised the need to rule out lung contusions, as this type of injury impacts morbidity and mortality,[17] whereas Bochicchio et al. have highlighted the importance of ruling out head injury.[8] The highest priority should be given to all life- and limb-threatening injuries. These injuries must be treated as a medical emergency, or their presence ruled out prior to referring to a specialist burns unit. The consequences of prompt referral without thorough assessment can worsen patient outcome, with delayed management of missed diagnosis. This was shown by one study in which some patients required emergency fasciotomies, and one patient required immediate above-knee amputation on arrival

at the burns unit.[3] One could argue that this should have been recognised and managed pre-transfer. There was one case in our study that required emergency escharotomies that were not done by the referring hospital. Once patients are stabilised and ATLS cleared, they should be transferred to a regional burns unit where they can be managed with more sophisticated protocols. At our unit, major burns are managed according to Emergency Management of Severe Burns (EMSB) protocols. Advanced Burn Life Support (ABLS) protocols from the American Burn Association are also well established in other countries.

We understand that there are limitations to this study, in that there were a limited number of cases over a 6-year period. Moreover, data was collected retrospectively and was reliant on the accuracy of the documentation.

Conclusion

Our series indicates that blast-related burn injuries are generally uncommon in the civilian setting and differ to blast injuries seen in a military setting. Given that there is currently limited English literature available on civilian blast-related burn injuries, our study provides data that can contribute to future systematic reviews. In most cases, these injuries are of low severity and can be managed conservatively without referral to a burns unit if clinicians at non-specialist units are better trained and equipped with the appropriate tools and dressings. There is a need to implement this change, with the outcomes of minor burns management at non-specialist centres investigated. This may lead to better patient care, avoid unnecessary referrals and free resources at burns units for more serious cases.

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